THE EFFECT OF PROLONGED SITTING VERSUS BODY WEIGHT RESISTANCE EXERCISE ON POSTURAL STABILITY

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Active workstations make it possible to interrupt prolonged sitting during the office worker's day, alleviating some health risks. Interrupting prolonged sitting with use of a treadmill desk revealed positive effects on postural stability. The present study aimed to investigate the acute effect of breaking up prolonged sitting with body weight resistance exercise on postural stability. Eight sedentary adults participated in a randomised two treatment crossover design: 1) uninterrupted sitting for 5 hrs versus 2) interrupting sitting with 3 min of exercise every 30 min. On a pressure plate, postural stability tests were performed pre and post condition. Anteroposterior centre of pressure (CoP) amplitude and CoP distance showed a significant interaction in the bipedal eyes open test; use of resistance exercise decreased postural stability. This suggests other active workstations (e.g. walking desks) may be more effective.

KEY WORDS: sedentary, occupational health, balance, active workstation

INTRODUCTION: The negative effects of chronic prolonged sitting on cardiometabolic disease and cancer risk factors (including elevated postprandial glucose, insulin, and triglycerides) are well established (e.g. D'Agostino et al., 2004; Einarson, Machado & Henk Hemels, 2011). For large numbers of the population, contemporary desk-based jobs and lack of free time are barriers to interrupting prolonged sitting. The introduction of active workstations, such as standing and treadmill desks, make it possible to incorporate physical activity into the office worker's day. Active workstations have shown positive effects on health markers such as body composition, glucose and lipids, and quality of life, in addition to effects on work performance and cognition (Dunstan, 2015). Postural stability is considered a sensorimotor process which includes the functional integration of sensory afferent information from visual, vestibular and somatosensory systems, as well as central processing of sensory information, and selecting motor responses (Horak, 2006). Impaired postural stability is a risk factor associated with falls and can also negatively affect social interaction and mental health (Rubenstein, 2006). Since physical activity affects all levels of the sensorimotor process, postural stability is a good candidate health variable to help further understand the effects of prolonged sitting.
The first study to investigate the acute effect of a using a treadmill desk on postural stability (Charalambous et al., 2017) found breaking up 6.5 hrs of prolonged sitting with an accumulated two hrs of light-intensity treadmill desk walking had a positive effect on postural stability, specifically a reduced mediolateral (ML) and anteroposterior (AP) CoP amplitude. This finding suggests that use of treadmill desks, or taking regular walking breaks, could have neuromuscular benefits in addition to other health benefits that have been more widely investigated to date (e.g. Bailey & Locke, 2015; Champion et al., 2018; Torbeyns et al., 2014). Investigating whether the positive effects found with walking breaks would be elicited with other exercise modalities is necessary before recommendations on active workstations can be made. Body weight resistance exercises may offer an economical and less time consuming activity. Breaking up prolonged sitting with body weight resistance exercise has shown some physiological benefits (e.g. Dempsey et al., 2016), but biomechanical measures have not yet been assessed. The aim of this study was to investigate the acute effect of breaking up prolonged sitting with body weight resistance exercise on postural stability in sedentary adults.

METHODS: Eight sedentary (sitting time > 7 hr/day) adults (four male, four female; 1.72 ± 0.07 m; 80.6 ± 18.9 kg; body mass index: 27.1 ± 5.1 kg/m^2; age: 39.2 ± 11.6 years) participated in this study. The study was approved by the University's Research Ethics committee. All participants were free from any injuries in the past 12 months, passed a health screen questionnaire and gave their informed consent. The study design was a randomised two treatment acute crossover. Participants attended the University's Sport and Exercise Science Laboratories on three separate occasions; a familiarisation session, followed by two experimental days separated by ≥7 days. Participants refrained from moderate-to-vigorous physical activity for ≥ 72 hrs and did not consume alcohol or caffeine ≥ 24 hrs prior to testing. During the familiarisation session, participant height (Horltain Ltd., Crymych, UK) and mass (Tanita Corp., Tokyo, Japan) were recorded and participants watched a video and practiced the exercises to be performed. During the experimental days, participants attended the laboratory at 0900 after an overnight fast. The two experimental conditions were: (1) Uninterrupted sitting for 5 hrs: participants remained seated and refrained from excessive movement, only rising to void, and (2) Interrupted sitting: participants performed body weight resistance exercises every 30 min; a) half squats, b) wall push-ups, c) knee raises, d) calf raises. Each resistance exercise period consisted of eight 20 s sets of half squats, upright wall push-ups, knee raises, and calf raises, with the remaining 20 s due to transitions between exercises. A standardised breakfast was consumed 15 mins prior to the start of the experimental condition and standardised snack at 2.5 hrs. Other measures not presented here (e.g. blood glucose, cognitive tests) were taken intermittently during each experimental day. When sitting, participants were permitted to read, watch videos or work on a computer. Postural stability tests were conducted on a pressure plate (RS Footscan, RSscan International, Olen, Belgium; 0.58 m x 0.42 m; 33 Hz) immediately prior to and 15 min following the conclusion of each 5 hr experimental condition. Stability tests were; bipedal stance with eyes open and eyes closed and unipedal stance on the preferred standing leg with eyes open. Participants were barefoot and stood upright, feet together, with their hands on their hips (iliac crests). The supporting leg(s) maintained neutral hip and knee positions (0° flexion). In the unipedal stance, the non-supporting leg was raised behind the participant, with neutral hip and 90° knee flexion. To avoid inclusion of postural movements whilst the participant was stabilising the body after stepping onto the pressure plate, trials commenced after an initial 5 s period which included a verbal 3 s count down from a researcher. For each test, a 30 s trial was recorded following the count down, with the participants instructed to 'stand as still as possible'. Three trials of each test were recorded with 30 s rest between each trial and 1 min rest between each test (Pinsault & Vuillerme, 2009). During the resting periods, participant sat on a chair next to the pressure plate. For the eyes-open tests, participants focused on an eye-level stationary cross marked on the wall 3 m away from the pressure plate. The order of tests was consistent for all participants and experimental conditions. Trials were excluded from analysis if the participant removed their hands from their hips, opened their eyes (eyes closed condition) or their non-supporting leg touched the floor (unipedal stance). The variables calculated for each 30 s trial were total distance travelled of the CoP (CoP distance) and maximum displacement of the CoP in the ML (ML CoP amplitude) and AP (AP CoP amplitude) directions. Mean and SD values for the three trials in each test were calculated. Inter-trial reliability was deemed acceptable (ICC > 0.7 and CV < 20% for all variables). Using Microsoft SPSS (version 22.0, SPSS inc, Chicago), a Repeated Measures Factorial ANOVA was conducted to investigate the main effects of time (pre v post) and condition (sitting v resistance exercise) and the interaction effect of time and condition on the dependent variables measured (CoP distance, ML CoP amplitude and AP CoP amplitude). The alpha level for a statistically significant effect/interaction was $p < 0.05$.

RESULTS: All variables are presented in Figure 1. The only significant effects or interactions found were for AP CoP amplitude ($F(1,7) = 8.04$, $p = 0.03$) and CoP distance ($F(1,7) = 3.67$, $p = 0.04$) in the bilateral eyes open test. In both of these significant interactions, the resistance exercise condition resulted in a mean increase in CoP amplitude/distance between the pre and post condition measures.

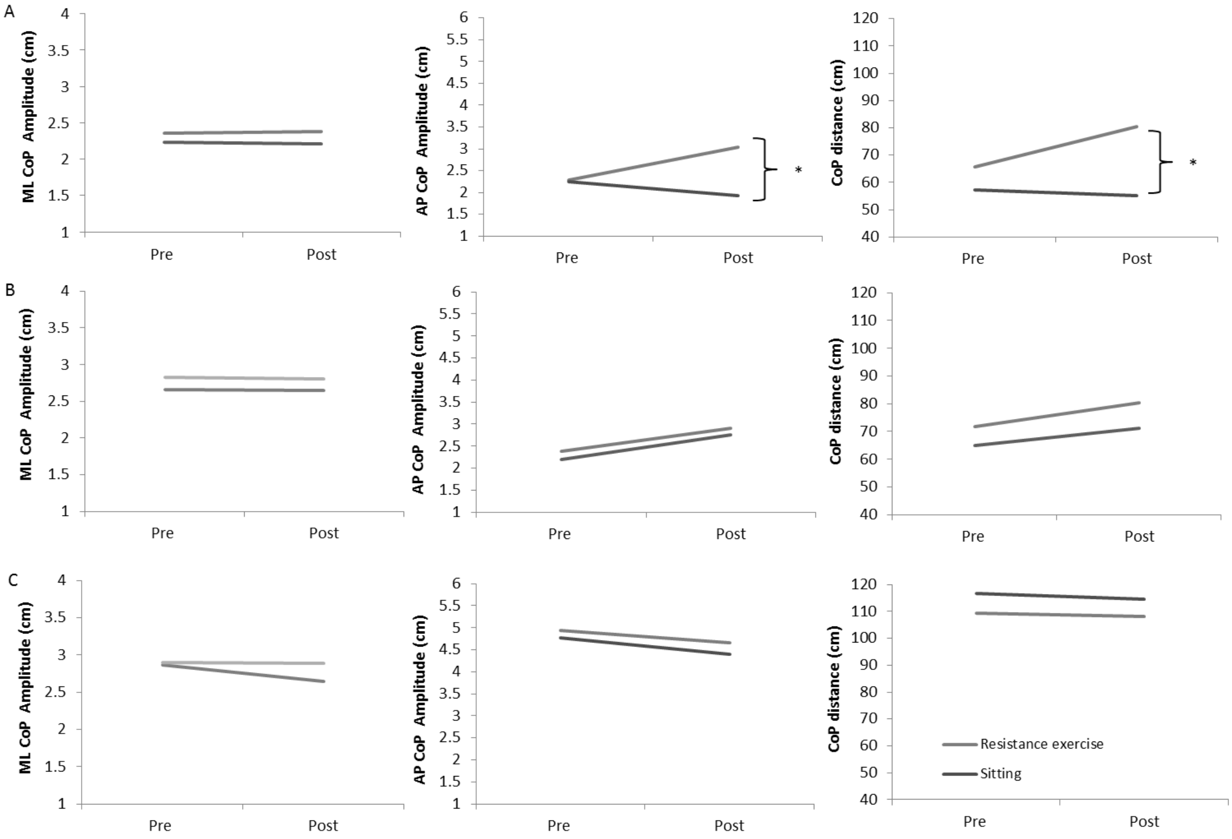

Figure 1. Profile plots of the resistance exercise (light grey) and sitting (dark grey) conditions during bipedal eyes closed (A), bipedal eyes open (B) and unipedal eyes open (C) tasks for ML CoP amplitude (left), AP CoP amplitude (centre) and CoP distance (right). A single asterisk (*) indicates a significant interaction (p < 0.05) between time (pre v post) and condition (sitting v resistance exercise).

DISCUSSION: The aim of this study was to investigate the acute effect of breaking up prolonged sitting with body weight resistance exercise on postural stability in sedentary adults. The main findings were significant interactions between time and sitting/resistance exercise condition for AP CoP amplitude and CoP distance in the bipedal eyes open test, but a lack of any other significant effects or interactions. The two significant findings can be interpreted as the resistance exercise having a negative effect on postural stability, since larger amplitude shifts in the CoP during quiet standing indicate a less efficient postural control system (Era et al. 1996). These results differ from a previous study where sitting interrupted with use of a walking desk had a positive effect on postural stability (Charalambous et al., 2017). Also unlike Charalambous et al. (2017), there was a lack of negative effect of uninterrupted sitting for 5 hrs on postural stability. Considering the previous study used a sitting duration of 6.5 hrs, it may be possible that the shorter duration does not cause the same negative effect on postural stability. Further studies are required to identify the time-course of such acute negative effects of prolonged sitting on postural stability.
The two negative interactions (AP CoP amplitude and CoP distance in the bipedal eyes open test) may be attributable to muscular fatigue. Whilst the chronic effects of being physically active on postural stability are positive (Enoka, 1997), it is accepted that even low intensity physical activity has an acute, short lasting (5-20 min) negative effect on postural stability (Fox et al., 2008). Localised muscle fatigue elicits an internal disturbance by disrupting proprioceptive functioning. The effect of muscle fatigue from resistance exercise has shown to reduce stability immediately following resistance exercise to fatigue (e.g. in older adults; Moore et al., 2005). Despite the exercises in the present study not being performed to fatigue and the post test being conducted 45 mins after the final exercise period, this was perhaps

not sufficient to allow recovery from this intensity of exercise. Furthermore, given that bipedal AP CoP amplitude is primarily controlled by triceps surae (soleus and gastrocnemius; Horak, 2006), the type of resistance exercises (included calf raises and half squats), may explain these particular findings.

This study adds to current knowledge regarding short term (acute) effects of physical activity on postural stability. The previous demonstration that prolonged sitting has a negative effect on these systems, but that this effect can be ameliorated by interrupting prolonged sitting with treadmill desk walking, supported treadmill desks as an effective tool for improving physical health and wellbeing in contemporary society (Charalambous et al., 2017). The findings that interrupting prolonged sitting with body weight resistance exercise does not have a similar positive effect, nor does the shorter time (6.5 hrs v 5 hrs) spent uninterrupted sitting have the same negative effects, should inform future studies on this topic and may have some practical implications. Whilst breaking up prolonged sitting with resistance exercise does have other benefits (e.g. Dempsey et al., 2016), it may be that walking is a better activity for eliciting positive effects on postural stability. It should also be recognised that there were some negative effects of resistance exercise breaks on postural stability, possibly due to calf muscle fatigue, and this may be an important consideration for exercise practitioners recommending body weight resistance exercises to patients with impaired stability (e.g. the elderly or diabetic patients).

CONCLUSION: Interrupting prolonged sitting with short bouts of body weight resistance exercise had some negative effects on postural stability, specifically a reduced AP CoP amplitude and CoP distance in the bipedal eyes open test. The implication of this finding suggests that use of other forms of breaking up prolonged sitting, such as walking, may be more suitable when postural stability requires maintenance.

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